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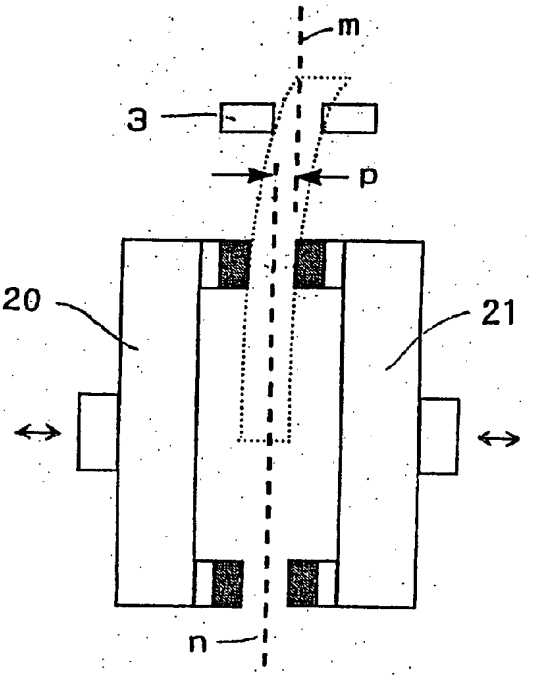
(54) METHOD AND DEVICE FOR SIMULTANEOUSLY GRINDING DOUBLE SURFACES, AND METHOD AND DEVICE FOR SIMULTANEOUSLY LAPPING DOUBLE SURFACES

(57) A double side simultaneous grinding (lapping) method and a double side simultaneous grinding (lapping) machine, in which a plate-like workpiece is held and ground (lapped) simultaneously for the both of front surface and back surface by using a pair of grinding stones (lapping turn tables) provided oppositely at both sides of the workpiece, wherein a relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone (turn table) surf of the pair of grinding stones (lapping turn tables) is controlled to perform the grinding (lapping). According to the present invention, in the double side simultaneous grinding (lapping) by using the double side simultaneous grinding (lapping) machine, there can be provided the double side simultaneous grinding (lapping) method and the double side simultaneous grinding (lapping) machine, wherein generation of warpage of the plate-like workpiece is suppressed, degradation of warpage which may be generated due to the grinding (lapping) is prevented, and thereby the plate-like workpiece can be processed to have high flatness for the both sides, besides, the platd-like workpiece can be ground (lapped) while a degree of warpage is controlled so that it should be processed to have warpage of a desired degree.

FIG. 3



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Description

Technical field

[0001] The present invention relates to a double side simultaneous grinding method with respect to platelike workpieces such as a semiconductor wafer or a quartz substrate for exposure original, a double side simultaneous grinding machine, a double side simultaneous lapping method, and a double side simultaneous lapping machine.

Background Art

[0002] Surface grinding has been used conventionally in a precision processing of plate-like workpieces such as semiconductor wafers or quartz substrates. The surface grinding has come to be used instead of a lapping etc., because the grinding rate is high, a wafer having high flatness is easily obtained, and so forth.

[0003] When a single side surface grinding machine is used in the grinding step, there is a problem that waviness generated in the previous step, i.e., slicing step, cannot be removed, because one side of a wafer is held by a vacuum suction and ground. In order to solve the problem, a double side simultaneous grinding machine (this machine is also referred to as "double head grinding machine") has been developed as a technique for simultaneously grinding both sides of a wafer.

[0004] As double head grinding method for simultaneously grinding the surfaces of a wafer, there are various methods, for example, creepfeed grinding method in which a wafer is put through between a pair of cylindrical grinding stones and thereby ground, and infeed grinding method in which a wafer is ground by using a pair of cup type grinding stones such that the grinding stones pass on the center of the wafer with the grinding stones and the wafer rotating together.

[0005] An infeed type double side simultaneous grinding machine la used for grinding of a semiconductor wafer, which is illustrated in Fig. 6, comprises a pair of cup type grinding stones 20, 21 rotating in the same directions, two pairs of plate-like workpiece press rollers 4 for supporting a plate-like workpiece W on its each side, four plate-like workpiece guide rollers 5 for supporting a circumference of the plate-like workpiece W, and a pair of plate-like workpiece driving-holding rollers 3 for rotating the grinding stones and holding the workpiece. The cup type grinding stones 20, 21 consist of a cup-shaped stock 2a, a grinding stone portion 2b and a grinding stone rotating shaft 2c. Grinding stone segments (not shown) are connected to a grinding surface of the grinding stone portion 2b. The plate-like workpiece W and the cup type grinding stones 20, 21 are rotated at a predetermined rotational speed. Grinding fluid is generally fed from a central hole (not shown) of the grinding stone rotating shaft 2c, or poured onto outer periphery or inside portion of the grinding stone.

[0006] In parallel with development of the double side simultaneous grinding machine is developed, double side simultaneous lapping machines of single wafer processing are also developed in place of conventional batch processing lapping machines with low accuracy and low productivity. The lapping process by using this single wafer processing lapping machine is a processing method having both advantages of the surface grinding which has high efficiency in processing and is automatized with high accuracy, and the lapping which obtains the same surface condition as that in conventional lapping, and besides an advantage that the back surface condition is equal to that in conventional lapping.

[0007] 'The double side simultaneous lapping machine has a structure of the infeed type double side simultaneous grinding machine la shown in Fig. 6, of which the pair of cup type grinding stones 20, 21 is replaced with flat lapping turn tables.. As to method of driving a plate-like workpiece, it adopts the same mechanism as that of the double side simultaneous grinding machine. Whereas, there is a wide difference in terms of the feeding manner of grinding stones or turn tables. The feeding manner of grinding stones in the double side simultaneous grinding machine is set by controlling a servomotor and the like, which is so-called. "infeed". On the other hand, since the turn tables of the lapping machine are basically controlled at a constant pressure, the turn tables are always supported by a pressurizing mechanism such as air cylinder.

[0008] As to a difference in actual processing of the plate-like workpiece, while the material operating in the double side simultaneous grinding machine is 'bonded abrasives of the cup type grinding stones, the double side simultaneous lapping machine uses lapping fluid (slurry) containing alumina abrasives etc. which are loose abrasives.

[0009] In recent years, the above-mentioned infeed type grinding method has been used generally because of the advantage that high flatness is easily obtained method, there is a problem that warpage (hereinafter may be also referred to as "warp") is apt to generate in the ground workpiece, due to unbalance of cutting loads on the both sides and so forth.

[0010] Meanwhile, there is disclosed a technique wherein coolant is injected from static pressure pads and thereby a plate-like workpiece is stably supported (for example, see Japanese Patent Laid-open Publication (Kokai) No. 9-262747). However, it has been found that only this technique cannot necessarily make a sufficient suppression of generation of warpage. Moreover, it has been found that the warpage of the wafer after double head grinding is apt to degrade than that before the grinding. Since it is difficult to remove this warpage in processing steps subsequent to the grinding step, these problems should be solved in the grinding step so as to seek further high flatness.

Disclosure of the Invention

[0011] The present invention has been accomplished in view of the above-mentioned problems, and its major object is to provide a double side simultaneous grinding method by using a double side simultaneous grinding machine, wherein generation of warpage of a plate-like workpiece is suppressed, degradation of warpage generated in the previous step is prevented, and thereby the plate-like workpiece can be processed to have high flatness for the both sides, and a double side simultaneous grinding machine having such the characteristic.

[0012] Another object is to provide a double side simultaneous grinding method, wherein a plate-like workpiece is ground while degree of warpage is controlled and thereby the workpiece can be processed to have a desired warpage, and a double side simultaneous grinding machine having such the characteristic.

[0013] Additionally, a double side simultaneous lapping machine which adopts almost the same structure as that of the double side simultaneous grinding machine has also almost the same problems as that of the double side simultaneous grinding machine described above. Another object of the present invention is to provide a double side simultaneous lapping method, wherein generation of warpage of a workpiece is suppressed, degradation of warpage generated in the previous step is prevented, and thereby the workpiece can be lapped to have high flatness for the both sides, and wherein the workpiece is lapped while a degree of warpage is controlled and thereby the workpiece can be processed to have a desired warpage, and a double side simultaneous lapping machine having such the characteristic.

[0014] In order to solve the aforementioned problems, the present invention provides a double side simultaneous grinding method in which a plate-like workpiece is held and simultaneously ground for the both sides by using a pair of grinding stones provided oppositely at both of front surface and back surface of the workpiece, wherein a relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone surfaces of the pair of grinding stones is controlled to perform the grinding.

[0015] The center of thickness of a plate-like workpiece is a reference set for defining a position of the plate-like workpiece, which is, for example, a line or plane passing points (center) of one half of thickness at two points, or three points or more on a surface of the plate-like workpiece.

[0016] As to the center of holding means for holding the plate-like workpiece, for example in case of the manner that the plate-like workpiece is supported on both of front surface and back surface of the workpiece, it means a virtual plane or line passing points of one half of distance between the pair of holding means provided at each side of the workpiece, namely a plane approximately parallel to the above-mentioned plane passing the center of thickness of the plate-like workpiece.

[0017] If the above plate-like workpiece has high flatness (parallelism), the center of holding means for holding the plate-like workpiece coincides with the center of thickness of the plate-like workpiece. That is, the center of holding means for holding the plate-like workpiece indirectly also reflects the center of thickness of the plate-like workpiece, i.e., the position of the plate-like workpiece.

[0018] Meanwhile, the center of space between stone surfaces of a pair of grinding stoned is a reference set for defining a position of the grinding stones, which is, specifically, a virtual line or plane passing points of one half of distance between the pair of grinding stones, and more specifically, a virtual line or plane passing middle points of space at two points, or three points or more on opposite grinding surfaces, namely a plane or line approximately parallel to the center of thickness of the plate-like workpiece.

[0019] That is, in the present invention, the grinding is performed while a relative position between an arbitrary reference plane or reference line for defining the position of the plate-like workpiece, and an arbitrary reference plane or reference line for defining the position of each grinding stone, more exactly, the position of each grinding surface is always controlled. In particular, when the relative position is controlled such that each reference plane of the plate-like workpiece and the grinding surfaces are parallel to each other, the control of warpage can be attained with high accuracy.

[0020] If, in the method for simultaneously grinding both sides of a plate-like workpiece, the grinding is performed while the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone surfaces of the pair of grinding stones is controlled as mentioned above, generation of warpage in the grinding step can be prevented and degradation of warpage generated in the previous step can be suppressed, so that whole surfaces of both sides of the plate-like workpiece can be processed to have high flatness. Accordingly, in the grinding step, increase of yield and improvement of productivity can be attained, and therefore cost can be improved. Further, warpage having an arbitrary degree can be formed on purpose, direction of warpage can also be controlled, and thus the method can be applied to provide characteristics demanded for use of the plate-like workpiece.

[0021] In this case, the grinding can be performed while the center of thickness of the plate-like workpiece and/or the center of holding means for holding the plate-like workpiece are/is always consistent with the center of space between the stone surfaces of the pair of grinding stones.

[0022] If the grinding is performed while the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece are/is al-

ways consistent with the center of space between the surfaces of the pair of grinding stones as mentioned above, warpage is hardly formed and 'degradation of warpage generated in the previous step can be suppressed, so that whole surfaces of both sides of the plate-like workpiece can be processed to have high flatness. Accordingly, yield and productivity in the grinding step can be increased, and therefore cost can be improved.

[0023] In this case, the grinding is desirably performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the surfaces of the pair of grinding stones is controlled so as to be 3μm or less.

[0024] If the grinding is performed while the difference between both centers is controlled so as to be 3μm or less as mentioned above, generation of warpage is certainly prevented, so that whole surfaces of both sides of the plate-like workpiece can be processed to have further higher flatness.

[0025] Further, in this case, the grinding can be performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the surfaces of the pair of grinding stones is controlled so as to be a desired value.

[0026] If the grinding is performed while the difference between both centers is controlled so as to be a desired value as mentioned above, warpage having an arbitrary degree can be formed, direction of warpage can be controlled, and thus the method can meet the requirements for characteristics of the plate-like workpiece.

[0027] The present invention also provides a double side simultaneous grinding machine having at least a holding means for holding a plate-like workpiece and a grinding means for simultaneously grinding the both of front surface and back surface by using a pair of grinding stones provided oppositely at both sides of the workpiece, wherein the machine is provided with a controlling means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone surfaces of the pair of grinding stones.

[0028] The means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone surfaces of the pair of grinding stones is, for example, a means for controlling a position of the line or plane passing points of one half of thickness at two points, or three points or more on a surface of the plate-like workpiece and/or the virtual line or plane, parallel to the grinding surfaces, passing points of one half of distance between the pair of holding means when the plate-like workpiece is supported on both of front surface and back surface of the workpiece, relative to the reference set for defining a position of the grinding stones, e.g., the virtual line or plane passing points of one half of distance between the pair of grinding stones provided oppositely, similar to the aforementioned reference set for defining the position of the plate-like workpiece.

[0029] If the double side simultaneous grinding machine is provided with the controlling means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the and the center of space between stone surfaces of the pair of grinding stones as mentioned above, the grinding can be performed while the relative position of both centers is controlled, and thereby generation of warpage in the grinding step can be prevented. Therefore, the machine can process the plate-like to have high flatness for whole surfaces of the both sides. Accordingly, if the plate-like workpiece is ground by using this double side simultaneous grinding machine, yield and productivity in the grinding step can be increased, and therefore cost can be improved. Besides, warpage having an arbitrary degree can be formed, direction of warpage can be controlled, and thus the machine can meet the requirements for individual characteristics of plate-like workpieces.

[0030] In this case, the double side simultaneous grinding machine is provided with the means for controlling the relative position which comprises a means for detecting a position of the holding means for holding the plate-like workpiece, a means for detecting positions of each grinding stone surface, a computer for processing these results of detection, and a means for moving the position of the holding means and/or the grinding stones based on the data processed by the computer. Actuator such as motor, the means for moving the position of the holding means and/or the grinding stones.

[0031] If the machine has such a structure, the position of the holding means for holding the plate-like workpiece and the position of each grinding stone surface are always detected, these detection results are processed by a computer, the position of the holding means and/or the grinding stones is moved based on the data processed by the computer, so that the workpiece is held in position to be ground. Therefore, the machine can process the plate-like workpiece to have high flatness for whole surfaces of the both sides. Accordingly, if the plate-like workpiece is ground by using this double side simultaneous grinding machine, yield and productivity in the grinding step can be increased, and therefore the cost can be improved.

[0032] In this case, it is desired that the means for controlling the relative position controls the elative position so as to be 3μm or less, or to be constant at a predetermined value.

[0033] If the grinding is performed by using the double side simultaneous grinding machine having the controlling means capable such control with high accuracy, the machine can process the plate-like wokpiece further certainly to have high flatness for whole surfaces of the both sides.

[0034] The present invention also provides a double side simultaneous lapping method in which a plate-like workpiece is held and lapped simultaneously for the both of front surface and back surface by using a pair of lapping turn tables provided oppositely at both sides of the workpiece, wherein a relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables is controlled to perform the lapping.

[0035] The definition of the wordings such as the center of thickness of the plate-like workpiece, the center of holding means for holding the workpiece, the center of space between turn table surfaces of the pair of lapping turn tables is the same as those defined in the aforementioned double side simultaneous grinding method.

[0036] If, in the method for simultaneously lapping both sides of a plate-like workpieces, the lapping is performed while the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables is in the lapping step can be prevented and degradation of warpage generated in the previous step can be suppressed, so that whole surfaces of both sides of the plate-like workpiece can be processed to have high flatness. Accordingly, yield and productivity in the lapping step can be increased, and therefore the cost can be improved. Further, warpage having an arbitrary degree can be formed on purpose, direction of warpage can also be controlled, and thus the method can be applied to provide characteristics demanded for use of the plate-like workpiece.

[0037] In this case, the lapping can be performed while the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece are/is always consistent with the center of space between the turn table surfaces of the pair of lapping turn tables.

[0038] If the lapping is performed while the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece are/is always consistent with the center of space between the surfaces of the pair of lapping turn tables, warpage is hardly formed and degradation of warpage generated in the previous step can be suppressed, so that whole surfaces of both sides of the plate-like workpiece can be processed to have high flatness. Accordingly, yield and productivity in the lapping step can be increased, and therefore cost can be improved.

[0039] In this case, the lapping is preferably performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the turn table surfaces of the pair of lapping turn tables is controlled so as to be 3μ m or less.

[0040] If the lapping is performed while the difference between both centers is controlled so as to be 3μm or less as mentioned above, generation of warpage is certainly prevented, so that whole surfaces of both sides of the plate-like workpiece can be processed to have further higher flatness.

[0041] Further, in this case, the lapping can be performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the surfaces of the pair of lapping turn tables is controlled so as to be a desired value.

[0042] If the lapping is performed while the difference between each center is controlled so as to be a desired value as mentioned above, formation of warpage having an arbitrary degree and control of direction of warpage can be realized, and thus the method can meet the requirements for characteristics of the plate-like workpiece.

[0043] The present invention also provides a double side simultaneous lapping machine having at least a holding means for holding a plate-like workpiece and a lapping means for simultaneously lapping the both of front surface and back surface by using a pair of lapping turn tables provided oppositely at both sides of the workpiece, wherein the machine is provided with a controlling means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables.

[0044] The means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables, is similar to the reference set for defining the position of the plate-like workpiece and previously described in the section concerning the double side simultaneous grinding machine.

[0045] If the double side simultaneous lapping machine is provided with the controlling means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables as mentioned above, the lapping can be performed while the relative position of both centers is controlled, and thereby generation of warpage in the lapping step can be prevented. Therefore, the machine can process the plate-like workpiece to have high flatness for whole surfaces of the both sides. Accordingly, if the plate-like workpiece is lapped by using this double side simultaneous lapping machine, yield and productivity in the lapping step can be increased, and therefore cost can be improved. Besides, warpage having an arbitrary degree can be formed, direction. of warpage can be controlled, and thus the machine can meet the requirements for individual characteristics of plate-like workpieces.

[0046] In this case, the double side simultaneous lapping machine is provided with the means for controlling the relative position which comprises a means for detecting a position of the holding means for holding the plate-like workpiece, a means for detecting positions of each lapping turn table surface, a computer for processing these results of detection, and a means for moving the position of the holding means and/or the lapping turn tables based on the data processed by the computer.

[0047] If the machine has such a structure, the position of the holding means for holding the plate-like workpiece and the positions of each lapping turn table surface are always detected, these detection results are processed by a computer, the position of the holding means and/or the lapping turn tables is moved based on the data processed by the computer, so that the workpiece is held in position to be lapped. Therefore, the machine can process the plate-like workpiece to have high flatness for whole surfaces of the both sides. Accordingly, if the plate-like workpiece is lapped by using this double side simultaneous lapping machine, yield and productivity in the lapping step can be increased, and therefore cost can be improved.

[0048] In this case, it is desired that the means for controlling the relative position controls the relative position so as to be 3μm or less, or to be constant at a predetermined value.

[0049] If lapping is performed by using the double side simultaneous lapping machine having the controlling means capable such control with high accuracy, the machine can process the plate-like wokpiece further certainly to have high flatness for whole surfaces of the both sides.

[0050] According to the present invention, in the double side simultaneous grinding by using a double side simultaneous grinding machine, generation of warpage of a plate-like workpiece is suppressed, degradation of warpage which may be generated due to the grinding is prevented, and thereby the plate-like workpiece can be processed to have high flatness for the both sides, and additionally yield and productivity can be increased and therefore cost can be improved.

[0051] Moreover, according to the present invention, the grinding can be performed while a degree of warpage is controlled, and thereby the workpiece can be processed to have warpage of a desired degree.

[0052] Further, according to the present invention, in the double side simultaneous lapping by using the double side simultaneous lapping machine, generation of warpage of the plate-like workpiece is suppressed, degradation of warpage generated in the previous step is prevented, and thereby the plate-like workpiece can be processed to have high flatness for the both sides, and additionally yield and productivity can be increased and therefore cost can be improved.

[0053] Moreover, according to the present invention, the lapping can be performed while a degree of warpage is controlled, and thereby the workpiece can be processed to have warpage of a desired degree. Brief Explanation of the Drawings

[0054] Fig. 1 is schematic explanatory views of an exemplary double side simultaneous grinding machine according to the present invention: (a) plan view, (b) front view, and (c) side view.

[0055] Fig. 2 is an explanatory view of action in a case that a double head grinding stone shaft is tilted.

[0056] Fig. 3 is an explanatory view of action where there is a discrepancy between the center of a plate-like workpiece holding means and the center of space between grinding stone surfaces according to the present invention.

[0057] Fig. 4 is a graph representing a relation between the shift amount of tilt of double head grinding stone shaft and the variation in warp.

[0058] Fig. 5 is a graph representing a relation between the position of a reference grinding stone and the variation in warp according to the present invention.

[0059] Fig. 6 is is schematic explanatory views of an exemplary conventional double side simultaneous grinding machine: (a) plan view, (b) front view, and (c) side view.

[0060] Fig. 7 is schematic explanatory views of an exemplary double side simultaneous lapping machine according to the present invention: (a) plan view, (b) front view, and (c) side view.

Best Mode for Carrying out the Invention

[0061] Embodiments of the present invention will be explained hereafter. However, the present invention is not limited to these.

[0062] Further, although the following explanation mainly refers to a double side simultaneous grinding method and a double side simultaneous grinding machine, the explanation may also be applied to a double side simultaneous lapping method and a double side simultaneous lapping machine, because in examples described later it is confirmed that the lapping has the same problems as those in the grinding and can obtain similar effect by using similar means to those in the grinding. Accordingly, unless there is a special mention, replacement of the word "grinding" by "lapping" and replacement of t'he word "grinding stone" by "turn table" in the explanations of the double side simultaneous grinding method and the double side simultaneous grinding machine make the explanations of the double side simultaneous lapping method and the double side simultaneous lapping machine.

[0063] As described above, when a plate-like workpiece is simultaneously ground for the both sides, in the conventional infeed type grinding there has been problems that warpage is apt to generate due to unbalance of cutting loads on the both sides, warpage is inclined to grow worse than before the grinding, and so on. Since it is difficult to remove this warpage in processing steps subsequent to the grinding step, the above problems of

warpage should be solved in the grinding step so as to seek further high flatness.

[0064] In order to solve the above problems, the inventors of the present invention searched the structure of an infeed type double side simultaneous grinding machine, its processing accuracy, etc., and then experimentally searched and studied the causes of generation and degradation of warpage. As a result, they found that in the double head grinding, the parallelism between stone surfaces of two grinding stones and a plate-like workpiece, the relative position between the pair of grinding stones and the plate-like workpiece, and the grinding force remarkably affect the warpage. Especially, they found that, if the grinding is performed while the center of thickness of the plate-like workpiece (the center of the laminer workpiece holding means) and the center of space between the surfaces of the pair of grinding stones are always consistent with each other, the plate-like workpiece has hardly any warpage for the both sides and can be processed to have high flatness. In addition, they also found that, if the grinding is performed while the above-mentioned difference (discrepancy) between both centers is controlled so as to be a desired value, the platelike workpiece having warpage of the desired degree can be produced. Thus, they investigated various grinding conditions, and accomplished the present invention.

[0065] First, a double side simultaneous grinding machine and a double side simultaneous lapping machine will be explained with reference to the drawings. Because the double side simultaneous lapping machine is not so different from the double side simultaneous grinding machine in terms of the structure of machine, the double side simultaneous grinding machine will be described below ([ ] represents the terms and references of the double side simultaneous lapping machine).

[0066] Fig. 1 [Fig. 7] is schematic explanatory views for explaining a schematic structure of an exemplary double side simultaneous grinding machine [double side simultaneous lapping machine] according to the present invention.

[0067] The infeed type double side simultaneous grinding machine [double side simultaneous lapping machine] of the present invention is an apparatus having a structure for simultaneously grinding [lapping] both sides of a plate-like workpiece, e.g., a semiconductor wafer. As shown in Fig. 1 [Fig. 7], a double side simultaneous grinding machine 1 [double side simultaneous lapping machine 50] comprises a pair of cup type grinding stones 20, 21 [lapping turn tables 51, 52] rotating in the same directions, two pairs of plate-like workpiece press rollers 4 [54] for supporting a plate-like workpiece W on its each side, four plate-like workpiece guide rollers 5 [55] for supporting a circumference of the plate-like workpiece W, and a pair of plate-like workpiece driving-holding rollers 3 [53] for rotating the plate-like workpiece W in the opposite direction to the grinding stones [turn tables] and holding the workpiece. Further, in the double side simultaneous lapping machine, the processing may be performed while the pair of lapping turn tables 51, 52 is rotated in the opposite directions to each other. The cup type grinding stones 20, 21 [lapping turn tables 51, 52] consist of a cup shaped stock 2a [turn table bearer 56], a grinding stone portion 2b [turn table surface portion 57] and a grinding stone rotating shaft 2c [turn table rotating shaft 58]. Grinding stone segments (not shown) are connected to a grinding surface of the grinding stone portion 2b. The plate-like workpiece W and the cup type grinding stones 20, 21 [lapping turn tables 51, 52] are rotated at a predetermined rotational speed. Grinding fluid [lapping fluid] is generally fed from a central hole (not shown) of the grinding stone rotating shaft 2c [turn table rotating shaft 58], or poured onto outer periphery or inside portion of the grinding stones [turn tables].

[0068] The apparatus for controlling degree of warpage according to the present invention comprises, for example, a plate-like workpiece holding means (plate-like workpiece) center detector 9 [60] for detecting the center of thickness of the plate-like workpiece and/or the center of the plate-like workpiece holding means which comprises the plate-like workpiece press rollers 4 [54], the plate-like workpiece guide rollers 5 [55] and the plate-like workpiece driving-holding rollers 3 [53] for holding the workpiece, a grinding stone [turn table] surfaces space center detector 10 [61] for detecting the center of space between the grinding stone [turn table] surfaces, a computer 12 [63] for processing these detection results, and a plate-like workpiece holding means (plate-like workpiece) position controlling means 13 [64] for controlling the position of the plate-like workpiece holding means (plate-like workpiece) and a grinding stone [turn table] surfaces space controlling means 14 [65] for controlling the. difference between the grinding stones [turn tables], based on the data processed by the computer 12 [63]. As these controlling means, for example, actuator such as motor, air cylinder and hydraulic cylinder may be used. In the drawings, α and β represent controlled direction and shifting amount to be outputted by each controlling means.

[0069] Besides, in order to adjust parallelism between the plate-like workpiece W and the grinding [lapping] surfaces of the grinding stone portions 2b [turn table surface portions 57] of two grinding stones [turn tables], the apparatus may be provided with a grinding stone [turn table] shaft tilt angle controlling means 15 [66] for adjusting a tilt of grinding stone shaft 2c [turn table rotating shaft 58], so that the tilt angle can be adjusted in advance before grinding [lapping] by a stepping motor, etc. Furthermore, if the apparatus is provided with a grinding stone [turn table] shaft tilt angle detector 11 [62] for detecting the tilt angle of the grinding stone shaft 2c [turn table rotating shaft 58] and its detection result is processed by the computer 12 [63] and outputted to the grinding stone [turn table] shaft tilt angle controlling means 15 [66], the control of tilt angle of the grinding

stone [turn table] shaft can be automated. Here, δ represents controlled direction and tilt amount to be outputted by the grinding stone [turn table] shaft tilt angle controlling means.

[0070] Next, a grinding [lapping] method of the plate-like workpiece W through use of the above-described double side simultaneous grinding machine 1 [double side simultaneous lapping machine 50] will be explained. The plate-like workpiece W is set on the apparatus, in which the workpiece W is supported on its each side by two pairs of plate-like workpiece press rollers 4 [54], and at its circumference by four plate-like workpiece guide rollers 5 [55]. Subsequently, the center position of the plate-like' workpiece holding means (plate-like workpiece) and the center position of space between the grinding stone [turn table] surfaces are inputted to the computer 12 [63] and set up so as to obtain warpage of a desired degree. The tilt angles of two grinding stone [turn table] shafts are also adjusted to a predetermined value. Then, the plate-like workpiece W is rotated by the plate-like workpiece driving-holding rollers 3 [53], and the pair of cup type grinding stones 20, 21 [lapping turn tables 51, 52] with rotating comes close to the workpiece W from its each side such that the workpiece should be. sandwitched in between the grinding stones [lapping turn tables]. The grinding stone portions 2b [turn table surface portions 57] are brought into contact with the plate-like workpiece W, the plate-like workpiece W and the cup type grinding stones 20, 21 [lapping turn tables 51, 52] are rotated in opposite directions to each other, and thereby the grinding [lapping] is performed. During grinding [lapping], grinding fluid [lapping fluid] is fed from a central hole (not shown) of the grinding stone rotating shaft 2c [turn table rotating shaft 58], or poured onto outer periphery or inside portion of the grinding stone [turn table].

[0071] Hereinafter, tests for finding a grinding condition for preventing formation of warpage and suppressing degradation of warpage, and its results will be explained.

[0072] The grinding was performed by using a double side simultaneous grinding machine having controlling means as shown in Fig. 1.

[0073] As a plate-like workpiece material, a semiconductor silicon wafer having a diameter of 200 mm, a thickness of 775 μm, which had been sliced with a wire saw, was used.

[0074] A basic grinding condition is as follows.

Workpiece rotation number: 7-25 rpm,
Grinding:stone: infeed type cup type grinding stone having the approximately same diameter as that of the workpiece, which consists of a metal bonded grinding stone #600 or a vitrified bonded grinding stone #2000 (using diamond abrasive grains),
Grinding stone rotation number: 2000-3500 rpm,
Grinding stone feed rate: 60-300 μm/min,
Flow rate of grinding fluid (grinding water): 3-15 L/min, and
Grinding stock removal: 60 μm as total removals of both surfaces.

<Test for parallelism between wafer and grinding stones>

[0075] A wafer having high flatness was experimentally produced under an optimum condition for parallelism between a wafer and grinding stones (parallelism between a reference plane of the center of thickness of the plate-like workpiece and that of the center of space between stone surfaces of a pair of grinding stones).

[0076] By changing the tilt of shaft of the pair of grinding stones (a left grinding stone and a right grinding stone shown in the drawings, and hereinafter they are also referred to as "right-and-left grinding stones"), parallelism between the right-and-left grinding stones and the workpiece was varied. The workpiece was ground and then its warpage was measured. A metal bonded grinding stone #600 was used as the grinding stone.

[0077] The warpage was evaluated as a warp. The warp is represented as a difference between the highest point and the lowest point on the wafer surface from a designated reference plane of the wafer without sucking fixation. Specifically, the warp was measured through use of an ADE UG9700 (produced by ADE Co.).

[0078] A wafer having a little warpage (silicon wafer or glass substrate having high flatness, of which warp is zero) was set on the double side simultaneous grinding machine, and the grinding was performed with the tilt of the right-and-left grinding stone shaft being changed by a stepping motor of the grinding machine (shift amount of tilt of grinding stone shaft δ = -4, -2, 0, 2, 4 (μm)). This shift amount of tilt, δ, is represented as a distance to which a grinding stone portion contacted with the wafer was moved to the wafer side, or moved away from the wafer.

[0079] Fig. 2 shows grinding stones (one grinding stone 20 (left) and the other grinding stone 21 (right)) tilted with respect to a wafer W by the tilt amount, δ (μm), of a right-and-left grinding stone shaft.

[0080] The measurement results are shown in Fig. 4. In Fig. 4, the abscissa axis represents the shift amount of the tilted grinding stones, and the ordinate axis represents the variation in the warp, i.e., | "warp after grinding" - "warp before grinding" |.

[0081] This figure shows that, when the shaft is tilted 2 μm to the right, the variation in the warp can be minimized.

[0082] This is because the surfaces of the right-andleft grinding stones come to be parallel to the wafer by virtue of adjusting the tilt of the right-and-left grinding stone shaft, resulting in decrease of influence of warpage formed in the grinding. Accordingly, in order to perform grinding without causing warpage, such compensation of tilt of the grinding stone shaft is required.

<Test for relative position of wafer to grinding stones>

[0083] The optimum relative position of a wafer to grinding stones in case of using a double head grinding machine having the arrangement as shown in Fig. 1 was searched.

[0084] A wafer was fixed at a predetermined position and one grinding stone (left side) was regarded as a reference side grinding stone. The reference side grinding stone was shifted from its reference position to right side by 0, 5, 10, 15, 20, 25, or 30 μm, and thereby the wafer supporting position and the relative position of the reference side grinding stone were varied. After shifting of such position, the relative position between the reference side grinding stone and wafer supporting portions on the side of this grinding stone was fixed, the grinding stone and the like on the opposite side were moved corresponding to the proper grinding stock removal, and then the grinding was performed. After that, warpage of the wafer was measured.

[0085] The first position of the reference side grinding stone (reference position = 0) did not necessarily coincide with the center of the wafer, but was determined arbitrarily. Further, warpage of the material wafer was about 10 μm.

[0086] Fig. 3 represents warpage of a wafer (dotted line) formed when there is a discrepancy (difference) p between the center m of a pair of plate-like workpiece driving-holding rollers 3 fixed at a predetermined position (the center of thickness of the wafer), and the center n of space between surfaces of right-and-left grinding stones.

[0087] The results are shown in Fig. 5. In Fig. 5, the abscissa axis represents the distance to which the grinding stone is shifted, and the ordinate axis represents the variation in the warp, i.e., I "warp after grinding" - "warp before grinding" I.

[0088] This figure shows that when the relative position of the wafer to the grinding stone is varied, there exists the position of the reference side grinding stone wherein the variation in the warpage is minimized (the variation in warp = 0). And it also shows that when the reference side grinding stone is shifted from the optimum position, the wafer is deformed as shown in Fig. 3 and the degree of the warpage varies.

[0089] In this example, at the position wherein the reference side grinding stone is shifted from the reference position determined arbitrarily to right ide by about 15-20 μm, the amount of change in warp is minimized, and therefore it is revealed that this position is the most preferable one for the relative position between the wafer and the grinding stones. This optimum position is the position wherein the center of the wafer (the center of the wafer holding means) and the center of the grinding stones (the midpoint between right-and-left grinding surfaces) approximately coincide.

[0090] A conventional double side simultaneous grinding machine has been provided with an adjusting device of grinding stone shaft tilt for adjusting parallelism between the wafer and the right-and-left grinding stones, however, neither means for detecting a position of the center of thickness of the wafer (wafer holding means) and a position of the center of space between the surfaces of grinding stones, nor a device for adjusting the relative position thereof. Accordingly, in order to find the optimum position in the conventional double side simultaneous grinding apparatus, the aforementioned tests must be performed and compensation of the position of the grinding stones or the wafer is required.

[0091] If the optimum position of the wafer and the grinding stones is always monitored and controlling means is provided so as not to shift the relative position like the present invention, the aforementioned tests do not need to be performed. Furthermore, once the reference position is determined correctly and a detector of center of plate-like workpiece holding means 9 and a detector of center of space between grinding stone surfaces 10 are calibrated, in the subsequent grinding the workpiece can be ground stably without degradation of warpage.

[0092] Furthermore, Fig. 5 shows that when the reference side grinding stone is shifted from the reference position, the warpage of the wafer varies approximately in proportion to its shifting amount.

[0093] In the graph of Fig. 5, the warpage is degraded on the right of the optimum value (about 19 μm) of the position of the reference side grinding stone. That is, the warpage of the material wafer which was 10 μm is degraded to 1.6 μm.

[0094] On the other hand, it is revealed that the warpage is improved on the left of the optimum value and the warpage of the wafer after grinding is improved to about 5 μm.

[0095] Such result was obtained for the following reason. The material wafer was set to be curved convexly to the right (about 10 μm), and thus the wafer was ground so as to warp adversely. That is, it is revealed that by virtue of shifting from the optimum position to right or left side (varying the relative position between the wafer and the grinding surfaces), both the direction and the degree of warpage can be controlled arbitrarily.

[0096] From two kinds of tests described above, it is revealed that, if the position of the wafer relative to the grinding stones and the tilt of the grinding stone shaft are optimized, generation of warpage can be prevented and degradation of warpage can be suppressed.

[0097] Moreover, if amount and direction of the shifting are controlled to be desired values, the wafer having warpage of desired degree and direction can be produced.

[0098] That is, in the double side simultaneous grinding, when a wafer is not loaded or equally loaded on the both sides with two grinding stones (both sides of the wafer are under the same grinding condition), the coincidence of the center of thickness of the wafer and the center of space between the surfaces of grinding stones

is a necessary condition for preventing generation of warpage and suppressing degradation of warpage.

[0099] Accordingly, it is important to dispose the plate-like workpiece and the pair of grinding stones such that they are parallel to each other, and to set the condition before grinding such that the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the stone surfaces of the pair of grinding stones always coincide. Preferably, the grinding may be performed while the difference (discrepancy) between both centers is controlled so as to be 3μm or less. By virtue of such condition, the grinding without warpage can be achieved.

[0100] In order to certainly achieve the aforementioned object and suppress warpage, in the actual grinding, it is important to suppress to the utmost the variation of feed rate and rotational speed of grinding stones and the deflection of the grinding stone rotating shafts, to suppress the deflection of the grinding surfaces in rotating of the grinding stones, and thereby to keep the flatness.

[0101] Further, the following fact needs to be considered. Because the plate-like workpiece is not a complete rigid body, the workpiece may deform to some degree, or be pressed and bruised with the grinding stones and thereby the difference of grinding condition between the both sides is moderated, so that the variation of grinding stock removal is likely to occur.

[0102] Besides, when grinding force becomes large due to loading of grinding stones during grinding and the like, the force with which the grinding stones press the wafer (processing force) becomes large, which may cause deformation of the wafer in grinding. However, dressing of the grinding stones makes the grinding force smaller, and thereby the deformation of the wafer can be suppressed and the warpage can be improved.

[0103] In the double side simultaneous grinding machine, positioning of grinding stones is usually conducted according to decrease in thickness of the wafer due to grinding. However, it was revealed that the warpage could not be controlled only by positioning according to the decrease in thickness because of the variation of grinding conditions (abrasion wear of grinding stone or grinding stock removal), the deformation of the wafer, or the like, so that a discrepancy in the relative position between the wafer and the grinding stone's was caused.

[0104] Therefore, the double side simultaneous grinding machine of the present invention is provided with a means for detecting, compensating and controlling such discrepancy, with which the conventional double side simultaneous grinding machine has not been provided, and thereby this discrepancy is automatically compensated and controlled before grinding and during grinding. Thus, the present invention is provided with a means for controlling the relative position which has a means for detecting the position of holding means for holding the platelike workpiece and a means for detecting the positions of each surface of the grinding stones.

[0105] The controlling method may be performed by detecting positions of the wafer (wafer holding means) and each surface of the grinding stones all the time, processing these detecting results by a computer,.and moving the position of the wafer (wafer holding means') and/or the position of grinding stones based on the data processed by the computer.

[0106] If the grinding is performed while the difference (discrepancy) between the center of thickness of the plate-like workpiece and/or the' center of holding means for holding the workpiece, and the center of space between the stone surfaces of the pair of grinding stones is controlled so as to be a desired value, the control of the relative position enables the formation of warpage having an arbitrary degree and the control of direction of warpage.

[0107] In addition, the double side simultaneous grinding can control the direction of warpage, because the grinding stones set up as shown in Fig. 1 can be shifted both to right side and to left side of the position of the wafer, which is different from the single side grinding. Thus, if the advance examination in direction and degree of warpage of a material wafer is performed, a value of the warp can be decreased by controlling the warpage to have the opposite direction to the original direction.

[0108] Further, the warpage may be provided to the wafer on purpose, and then by virtue of a subsequent single side thin film formation the generated warpage may be eliminated.

[0109] The plate-like workpiece holding means in the double side simultaneous grinding machine has various types.

[0110] For example, the holding means shown in Fig. 1 is composed of plural holding means such as two pairs of plate-like workpiece press rollers 4 for supporting a plate-like workpiece W on its both sides, four plate-like workpiece guide rollers 5 for supporting a circumference of the plate-like workpiece W, a pair of plate-like workpiece driving-holding rollers 3 for rotating the plate-like workpiece W in opposite direction to the grinding stones and holding the workpiece, and so forth.

[0111] Meanwhile, there is another method wherein the workpiece is held by the pressure of coolant which is injected to the both sides of the workpiece with equal pressure from plural hydrostatic pads, and supported by plural plate-like workpiece guide rollers and a pair of plate-like workpiece driving-holding rollers for supporting the circumference of the plate-like workpiece.

[0112] When the holding means comprises plural components as described above, it is preferable to make the center of all holding means and the center of space between the surfaces of the pair of grinding stones coincide. However, even though all centers do not coincide, if the center of a holding means which defines the position of the plate-like workpiece most effectively of all holding means and the center of space be-

tween the grinding stone surfaces coincide, the machine can make the effect.

[0113] The control of the relative position of both centers may be conducted by the plate-like workpiece holding means, or conducted such that the plate-like workpiece is fixed at a predetermined position and the pair of grinding stones is shifted simultaneously or respectively.

[0114] In addition to the positioning according to decrease in thickness of the plate-like workpiece, this control of the relative position between the center of plate-like workpiece holding means and the center of space between the surfaces of the pair of discrepancy between the center of the holding means and the center of space between the grinding stone surfaces which is caused by the grinding pressure, the life of the grinding stones, or the like.

[0115] As a means for detecting a position of the plate-like workpiece (plate-like workpiece holding means) and positions of each grinding stone surfaces, one utilizing variation of reflection position of laser beam, or a detector for detecting the positions directly with various sensors such as air micrometer or electric micrometer may be used. A detector for indirectly detecting the mechanical positions of portions which place and hold the plate-like workpiece and the grinding stones may also be used. However, the detector for indirectly detecting the positions needs compensation in consideration of the grinding stock removal of the plate-like workpiece, the abrasion wear of the grinding stones, etc.

[0116] In order to adjust parallelism between a plate-like workpiece and grinding surfaces of two grinding stones, the machine may be provided with a grinding stone shaft angle controlling means for adjusting tilt of grinding stone shaft, so that the tilt angle can be adjusted in advance before grinding by a stepping motor, etc. The machine may also be equipped with a grinding stone shaft angle detector for detecting the tilt angle of the grinding stone shaft. Results of its detection are processed by a computer and then inputted to the above controlling means of tilt angle of grinding stone shaft, so that the control of tilt angle of the grinding stone shaft can be automated.

[0117] Hereafter, the present invention will be explained in detail with reference to examples of the present invention and comparative examples. However, the present invention is not limited to these.

(Example 1)

[0118] A pair of cup type grinding stones of vitrified bond #2000 (width of grinding stone portion: about 3 mm) having a diameter of 200 mm was mounted on a double side simultaneous grinding machine shown in Fig. 1, and then a semiconductor silicon wafer was ground.

[0119] The silicon wafer having a thickness of 775 μm and a diameter of 200 mm (8 inches), which had been sliced from ingot with a wire saw, was used.

[0120] A basic grinding condition was as follows; workpiece rotation number: 7-25 rpm, grinding stone rotation number: 2000-3500 rpm, grinding stone feed rate: 60-300 μm/min, flow rate of grinding water: 3-15 L/min, grinding stock removal: 60 μm as total removal of both surfaces, and so forth.

[0121] After the center of holding means for holding the workpiece and the center of space between the grinding stone surfaces were made to coincide manually on initial setting before grinding, the workpiece was simultaneously ground for the both sides under the same condition.

[0122] As a result, while the warp value before grinding was 5-25 μm, the warpage after grinding hardly changed as compared with that before grinding. The warpage was measured through use of an ADE UG9700 (produced by ADE Co.).

[0123] After grinding, it was confirmed that the difference between the center of wafer holding means and the center of space between the grinding stone surfaces had been controlled to be 3 μm or less.

(Comparative Example 1)

[0124] The grinding was performed under the same conditions as in the Example except that plural wafers were ground repeatedly without compensating a discrepancy between the center of wafer holding means and the center of space between the grinding stone surfaces.

[0125] As a result, while the warp value before grinding was 5-25 μm, generation of warpage after grinding gradually increased, and besides there was variation in the way of generating. It was seen that the warpage changed approximately 10 μm on average.

[0126] After grinding, it was observed that there was the discrepancy of 10 μm or more between the center of wafer holding means and the center of space space between the grinding stone surfaces.

(Example 2)

[0127] A pair of turn tables made of casting iron and having a diameter of 200 mm was mounted on a double side simultaneous lapping machine shown in Fig. 7, and then a semiconductor silicon wafer was lapped. As a lapping turn table, ring-shaped casting iron having a width of 50 mm which had been grooved was used.

[0128] The silicon wafer having a thickness of 775 μm and a diameter of 200 mm (8 inches), which had been sliced from ingot with a wire saw, was used.

[0129] A basic lapping condition was as follows; workpiece rotation number: 10 rpm, turn table rotation number: 500 rpm, lapping load: 100-300 gf/cm^2, lapping fluid: slurry containing alumina abrasives #1200, flow rate of slurry: 150 ml/min, and lapping removal: 60 μm

as total removal of both surfaces.

[0130] After the center of holding means for holding the workpiece and the center of space between the surfaces of the lapping turn tables were made to coincide manually on initial setting before lapping, the workpiece was simultaneously lapped for the both sides under the same condition.

[0131] As a result, while the warp value before lapping was 5-25 μm, the warpage after lapping hardly changed as compared with that before lapping. After lapping, it was confirmed that the difference between the center of wafer holding means and the center of space between the lapping turn table surfaces had been controlled to be 3 μm or less.

(Comparative Example 2)

[0132] The lapping was performed under the same conditions as in Example 2 except that plural wafers were lapped repeatedly without compensating a discrepancy between the center of wafer holding means and the center of space between the lapping turn table surfaces.

[0133] As a result, while the warp value before lapping was 5-25 μm, generation of warpage after lapping gradually increased, and besides there was variation in the way of generating. It was seen that the warpage changed approximately 10 μm on average.

[0134] After lapping, it was observed that there was the discrepancy of 10 μm or more between the center of wafer holding means and the center of space between the lapping turn table surfaces.

[0135] Further, the present invention is not limited to the embodiments described above. The above-described embodiments are mere examples, and those having the substantially same structure as that described in the appended claims and providing the similar functions and advantages are included in the scope of the present invention.

[0136] For example, although as double side simultaneous grinding machine [double side simultaneous lapping machine] there are a type for holding the plate-like workpiece vertically and a type for holding the plate-like workpiece horizontally, the present invention is not limited to the type and can be applied to any types.

[0137] While wafers sliced from a silicon single crystal ingot having a diameter of 200 mm (8 inches) are ground [lapped] in the embodiments of the present invention, the present invention can sufficiently be applied to recently used wafers having a diameter of 250 mm (10 inches) to 400 mm (16 inches) or larger.

Claims

1. A double side simultaneous grinding method in which a plate-like workpiece is held and ground simultaneously for the both of front surface and back surface by using a pair of grinding stones provided oppositely at both sides of the workpiece, characterized in that a relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone surfaces of the pair of grinding stones is controlled to perform the grinding.

2. The double side simultaneous grinding method according to Claim 1, characterized in that the grinding is performed while the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece are/is always consistent with the center of space between the stone surfaces of the pair of grinding stones.

3. The double side simultaneous grinding method according to Claim 1 or 2, characterized in that the grinding is performed while the differnce between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the stone surfaces of the pair of grinding stones is controlled so as to be 3μm or less.

4. The double side simultaneous grinding method according to Claim 1, characterized in that the grinding is performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the stone surfaces of the pair of grinding stones is controlled so as to be a desired value.

5. A double side simultaneous grinding machine having at least a holding means for holding a plate-like workpiece and a grinding means for simultaneously grinding the both of front surface and back surface by using a pair of grinding stones provided oppositely at both sides of the workpiece, characterized in that the machine is provided with a controlling means for controlling a relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between stone surfaces of the pair of grinding stones.

6. The double side simultaneous grinding machine for controlling the relative position comprises;

   a means for detecting a position of the holding means for holding the plate-like workpiece,
   a means for detecting positions of each grinding stone surface,
   a computer for processing these results of detection, and
   a means for moving the position of the holding

means and/or the grinding stones based on the data processed by the computer.

7. The double side simultaneous grinding machine according to Claim 5 or 6, characterized in that the means for controlling the relative position controls the relative position so as to be 3μm or less, or to be constant at a predetermined value.

8. A double side simultaneous lapping method in which a plate-like workpiece is held and lapped simultaneously for the both of front surface and back surface by using a pair of lapping turn tables provided oppositely at both sides of the workpiece, characterized in that a relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables is controlled to perform the lapping.

9. The double side simultaneous lapping method according to Claim 8, characterized in that the lapping is performed while the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece are/is always consistent with the center of space between the turn table surfaces of the pair of lapping turn tables.

10. The double side simultaneous lapping method according to Claim 8 or 9, characterized in that the lapping is performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the turn table surfaces of the pair of lapping turn tables is controlled so as to be 3μm or less.

11. The double side simultaneous lapping method according to Claim 8, characterized in that the lapping is performed while the difference between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between the turn table surfaces of the pair of lapping turn tables is controlled so as to be a desired value.

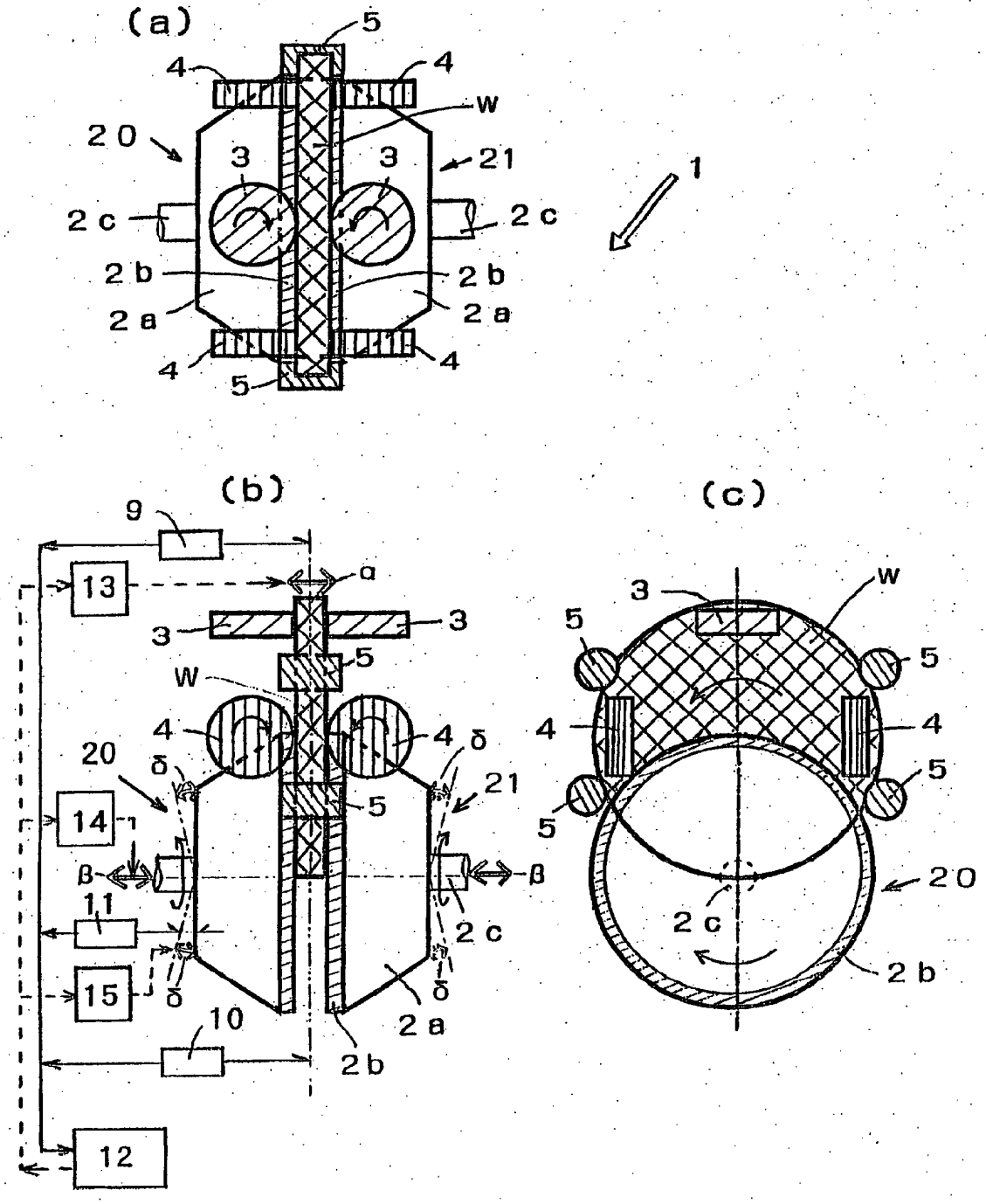
12. A double side simultaneous lapping machine having at least a holding means for holding a plate-like workpiece and a lapping means for simultaneously lapping the both of front surface and back surface by using a pair of lapping turn tables provided oppositely at both sides of the workpiece, characterized in that the machine is provided with a controlling means for controlling the relative position between the center of thickness of the plate-like workpiece and/or the center of holding means for holding the workpiece, and the center of space between turn table surfaces of the pair of lapping turn tables.

13. The double side simultaneous lapping machine according to Claim 12, characterized in that the means for controlling the relative position comprises;

a means for detecting a position of the holding means for holding the plate-like workpiece,
a means for detecting positions of each lapping turn table surface,
a computer for processing these results of detection, and
a means for moving the position of the holding means and/or the lapping turn tables based on the data processed by the computer.

14. The double side simultaneous lapping machine according to Claim 12 or 13, characterized in that the means for controlling the relative position controls the relative position so as to be 3μm or less, or to be constant at a predetermined value.

FIG.1


(a)
5
4
4
W
20
3
3
21
1
2c
2c
2b
2b
2a
2a
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4
5
(b)
9
13
α
3
3
5
W
4
4
δ
20
δ
21
5
14
β
β
11
2c
15
δ
δ
10
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2b
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(c)
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5
5
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2c
2b

FIG. 2

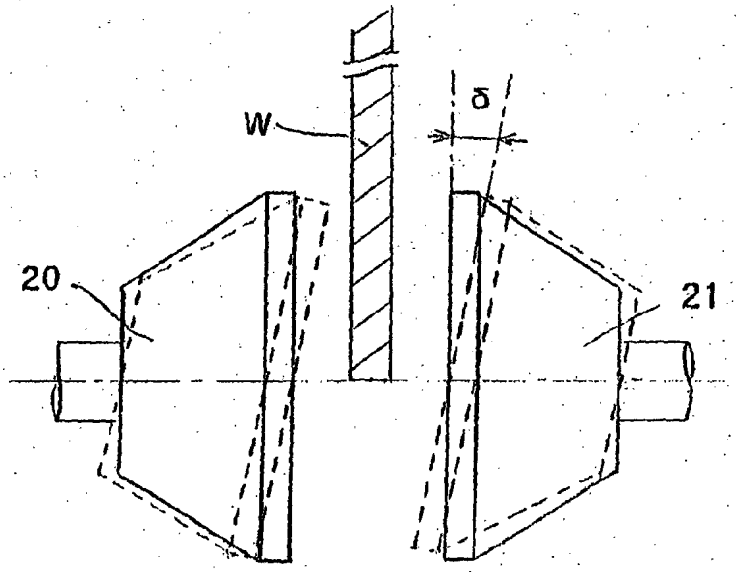
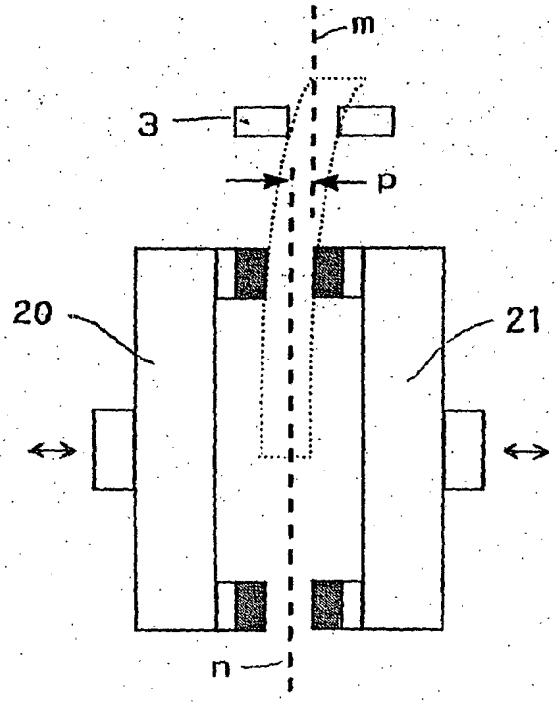


FIG. 3



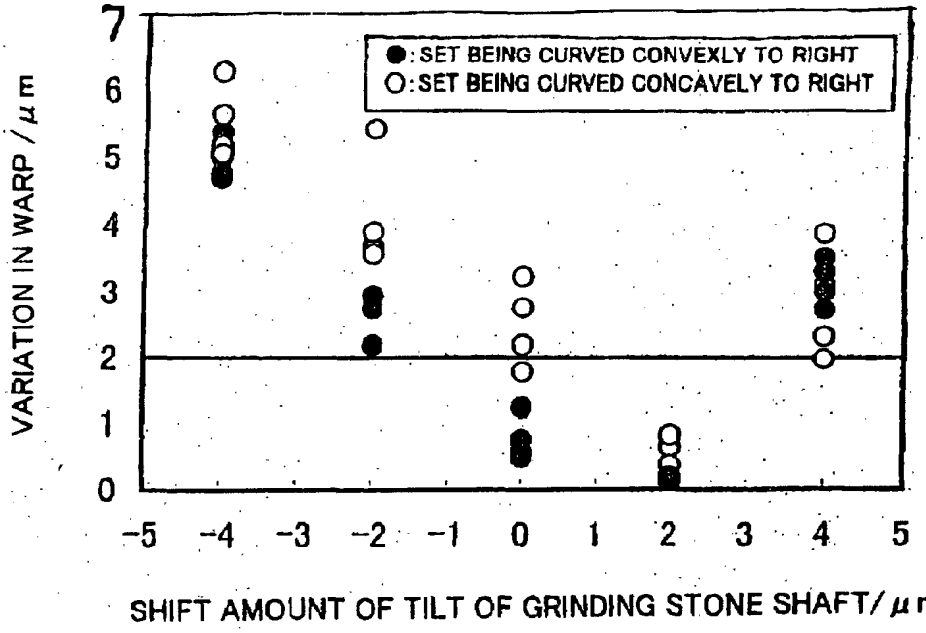
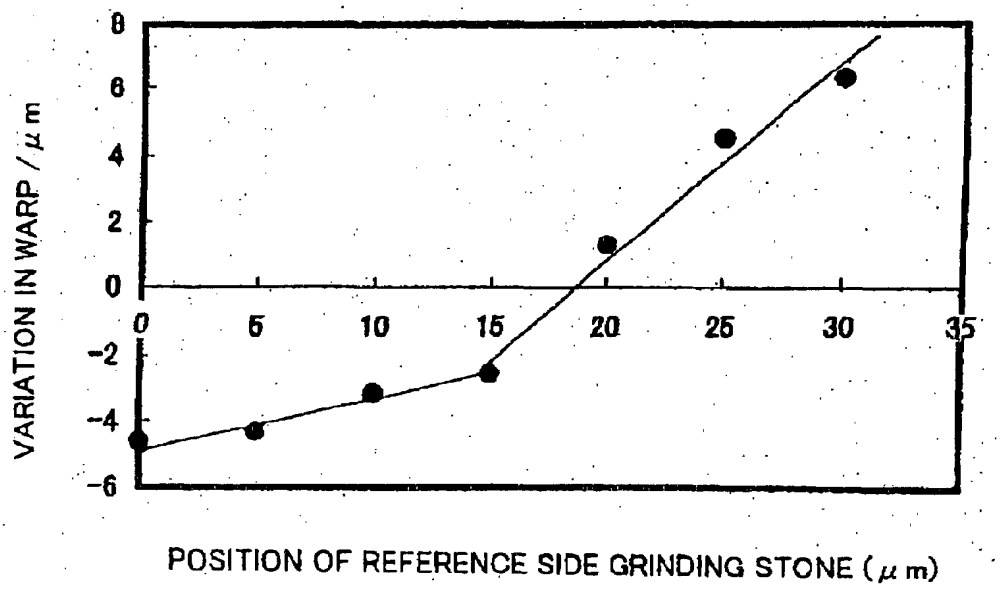

●:SET BEING CURVED CONVEXLY TO RIGHT
○:SET BEING CURVED CONCAVELY TO RIGHT
VARIATION IN WARP /μm
7
6
5
4
3
2
1
0
−5 −4 −3 −2 −1 0 1 2 3 4 5
SHIFT AMOUNT OF TILT OF GRINDING STONE SHAFT/μm

FIG.4

FIG. 5


VARIATION IN WARP /μm
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6
4
2
0
−2
−4
−6
0 5 10 15 20 25 30 35
POSITION OF REFERENCE SIDE GRINDING STONE (μm)

FIG. 6

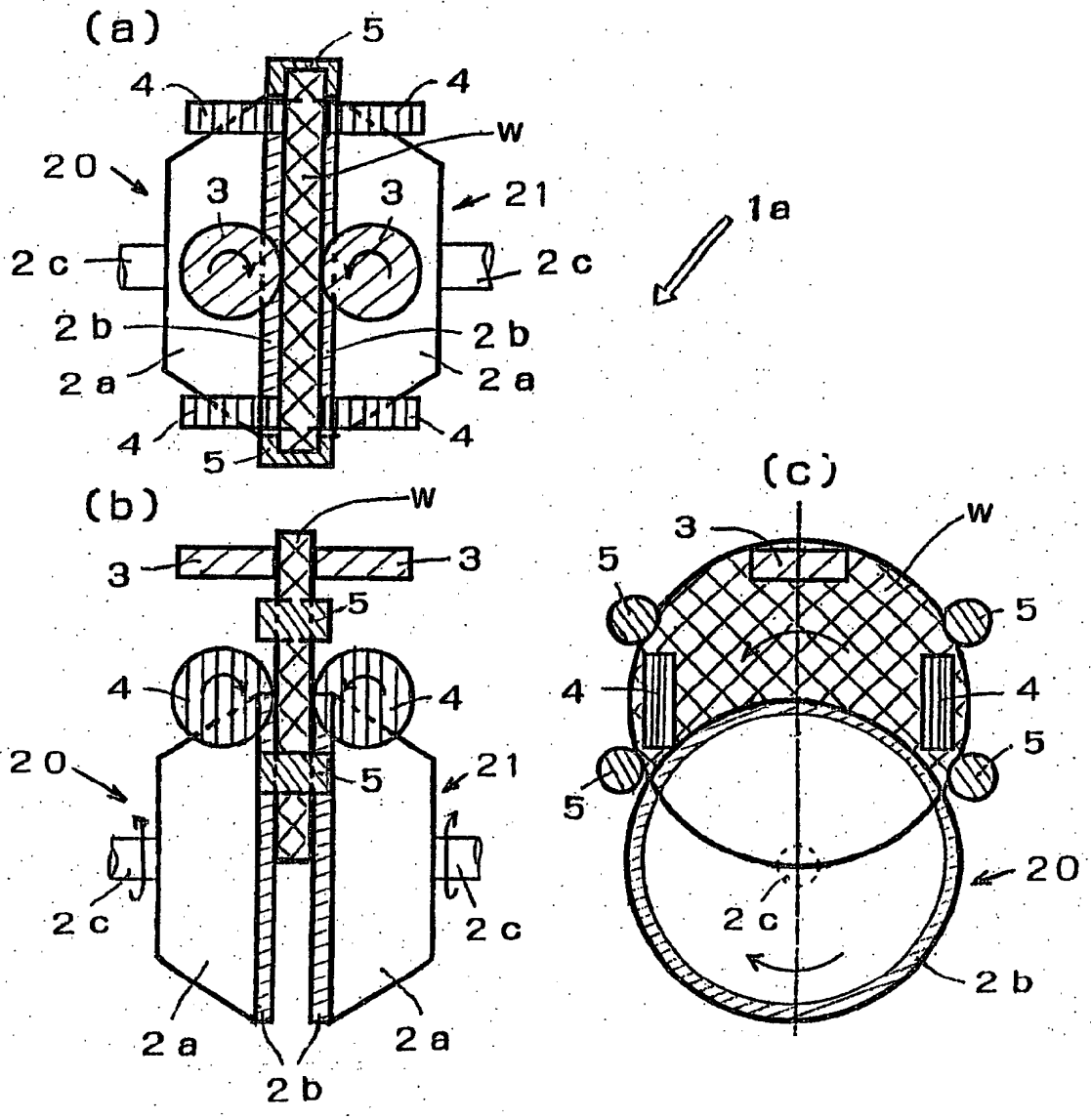
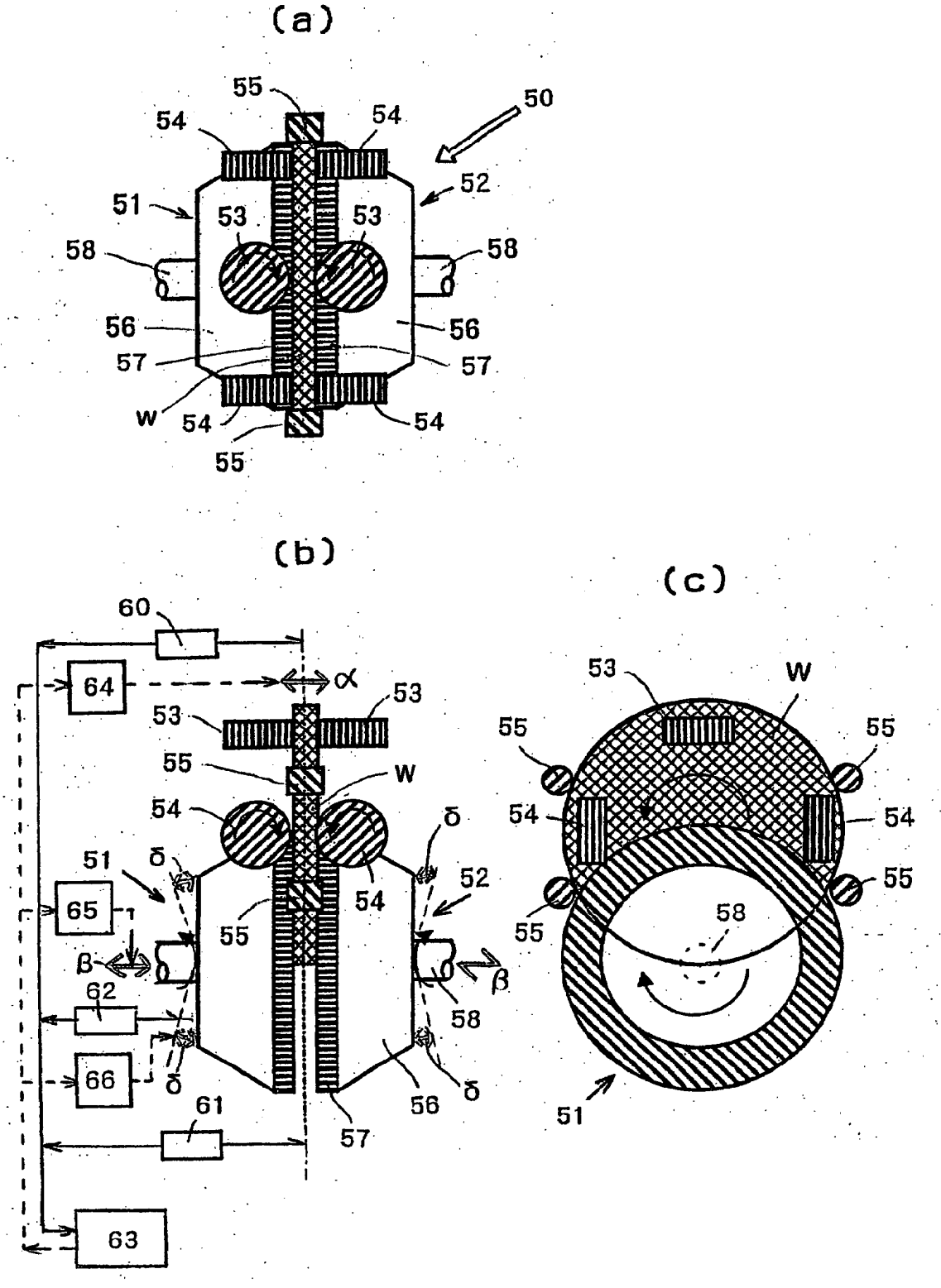

(a)
5
4
4
W
20
3
3
21
1a
2c
2c
2b
2b
2a
2a
4
4
5
(b)
W
3
3
5
4
4
20
5
21
2c
2c
2a
2a
2b
(c)
3
W
5
5
4
4
5
5
20
2c
2b

FIG. 7


(a)
55
54
54
50
52
51
53
53
58
58
56
56
57
57
W
54
54
55
(b)
60
64
α
53
53
55
W
54
δ
51
δ
52
65
54
55
β
β
62
58
66
δ
δ
61
56
57
63
(c)
53
W
55
55
54
54
55
55
58
51

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/02788

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B24B7/17, B24B37/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B24B7/17, B24B37/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1920-2000 Jitsuyo Shinan Toroku Koho 1996-1996
Kokai Jitsuyo Shinan Koho 1971-2000 Toroku Jitsuyo Shinan Koho 1994-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP, 10-217074, A (Toyo A Tec K.K.), 18 August, 1998 (18.08.98), page 4, Column 6, lines 19 to 26; Fig. 5 (Family: none)	1-3,8-10 4-7,11-14
X A	JP, 11-77497, A (Waida Seisakusho K.K.), 23 March, 1999 (23.03.99), page 4, Column 6, lines 14 to 22; Fig. 2 (Family: none)	1-3,8-10 4-7,11-14
A	JP, 9-272049, A (Kobe Steel, Ltd.), 21 October, 1997 (21.10.97), page 2, Column 2, line 46 to page 3, Column 3, line 11; Fig. 3 (Family: none)	1-14
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 169412/1983 (Laid-open No. 78236/1985) (Hitachi Zosen Corporation), 31 May, 1985 (31.05.85), Claims of utility model; Fig. 1 (Family: none)	1-14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 August, 2000 (15.08.00)	29 August, 2000 (29.08.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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